

AIAA Space 2011 Conference & Exposition

# Heavy Lift Capability with a New Hydrocarbon Engine (NHE)

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# Agenda



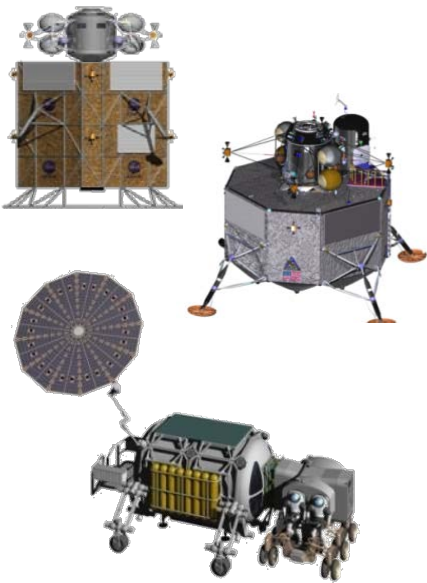
- **MSFC ACO Overview**
- **Study Objective/Approach**
- **Heavy Lift Concept Configurations**
- **Configurations Derived from the LRB**
- **Effect of Engine Out on 100 MT Configuration**
- **Summary**



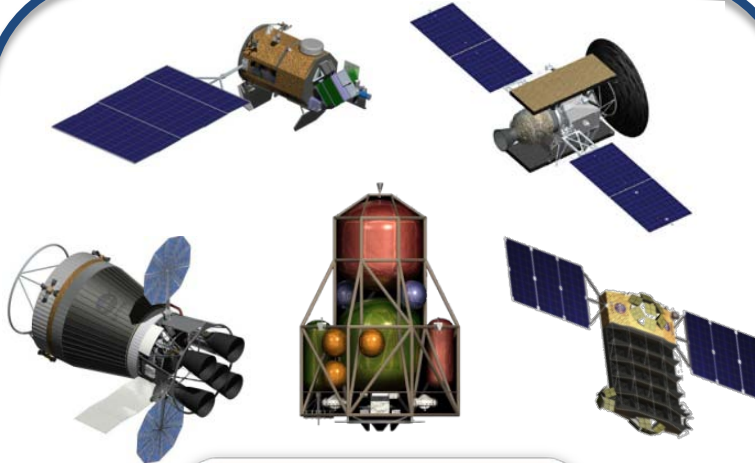
# MSFC Advanced Concepts Office



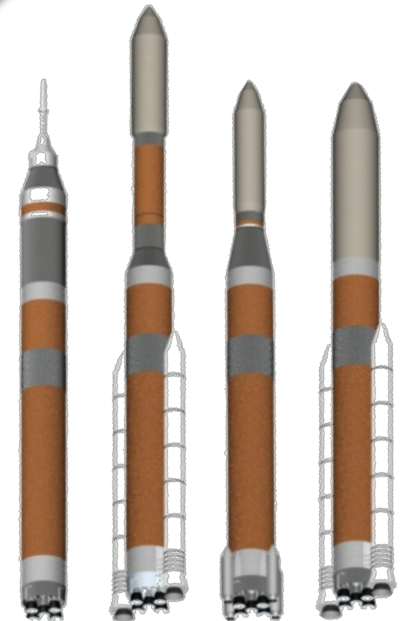
*We Are An Office Specializing In Pre-Phase A & Phase A Concept Definition*



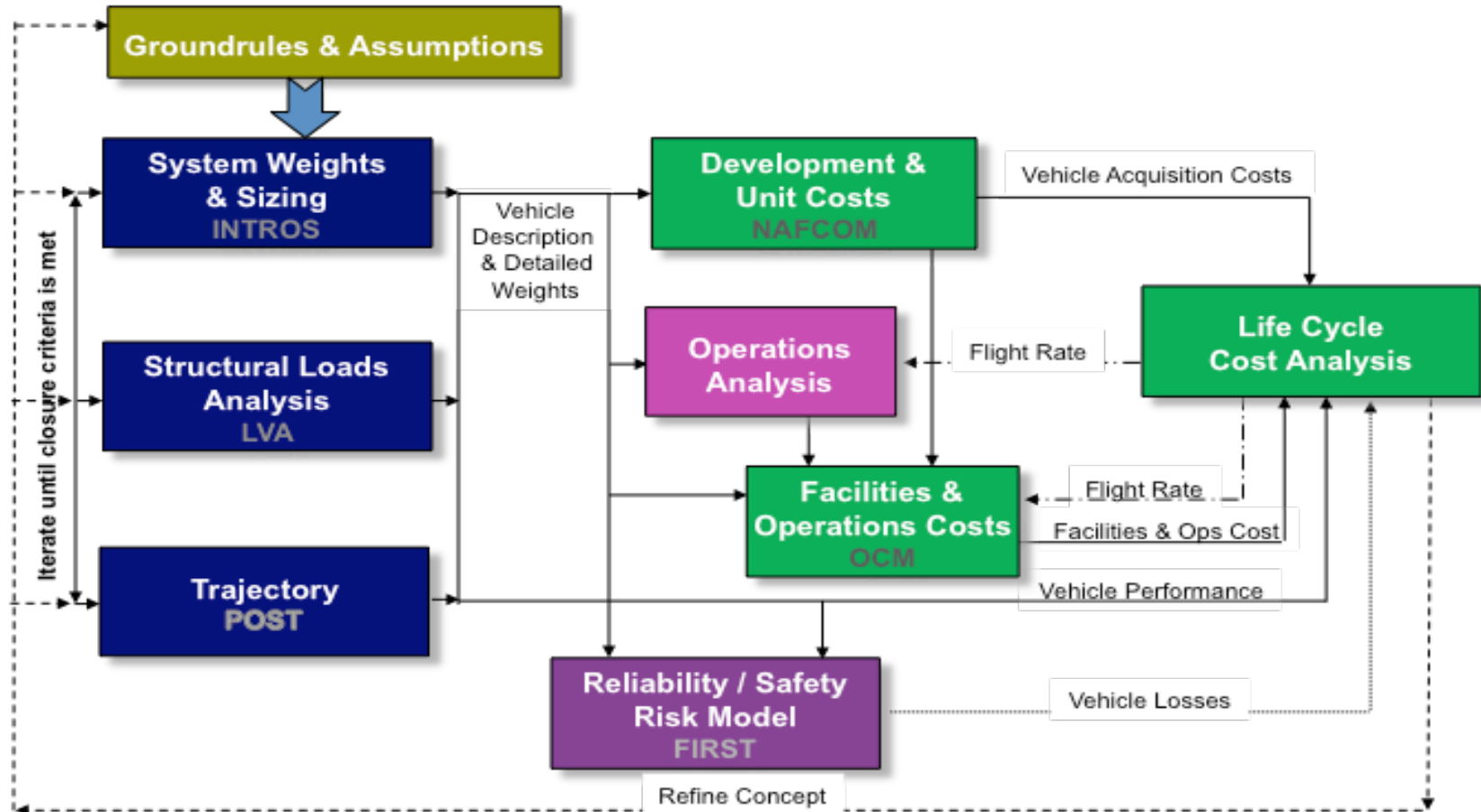
*Human Exploration  
Systems*



*In-Space  
Transportation and  
Science Systems*



*Launch Vehicle  
Systems*



Note: Cost and Reliability Analyses were not performed for this study



## Study Objective



***Determine the thrust requirement for a new LOX Rich Stage Combustion Kerosene (RP) Engine that can lift 100 MT to LEO in a 2 Stage series configuration... and by adding strapon LRBs with the same engine lift 140 MT using common stages to minimize design and development costs. Evaluate other potential concepts derived from the engine/stages.***



# Launch Vehicle Architecture and Element Commonality Approach Using NHE



**NASA Heavy Lift 1**  
100 MT



**NASA Heavy Lift 2**  
140 MT



**Potential  
DoD / Commercial  
Application**



Design for  
Common 2<sup>nd</sup> Stage  
with J-2X-285



Design for  
Common 1<sup>st</sup> Stage  
Add LRBs for increased  
Payload Requirements



Single Engine LRB  
Could become 1<sup>st</sup> Stage  
In New Launch Vehicle



Potential Use in New  
Reusable First Stage for Air Force

Not Analyzed in this Study



**NHE**

**Thrust Trades (1.0 Mlbf Vac – 1.3 Mlbf Vac Class)**





- Vehicle Stages up to 33 ft diameter
- Vehicle not higher than 390 ft
- Thrust / Weight at liftoff not less than 1.2
- NHE engine thrust to not exceed 1.3 Mlbf vacuum
- Ascent axial acceleration to not exceed 5.0 g
- NHE has continuous throttling capability
- Second Stage is LOX/LH2 using J2X-285



## NHE Engine Assumptions\*

- Vac Isp: 332 s
- T/W = 70
- Mixture Ratio: 2.7
- Engine Length: 180 in.
- Engine Nozzle Diam: 120 in.

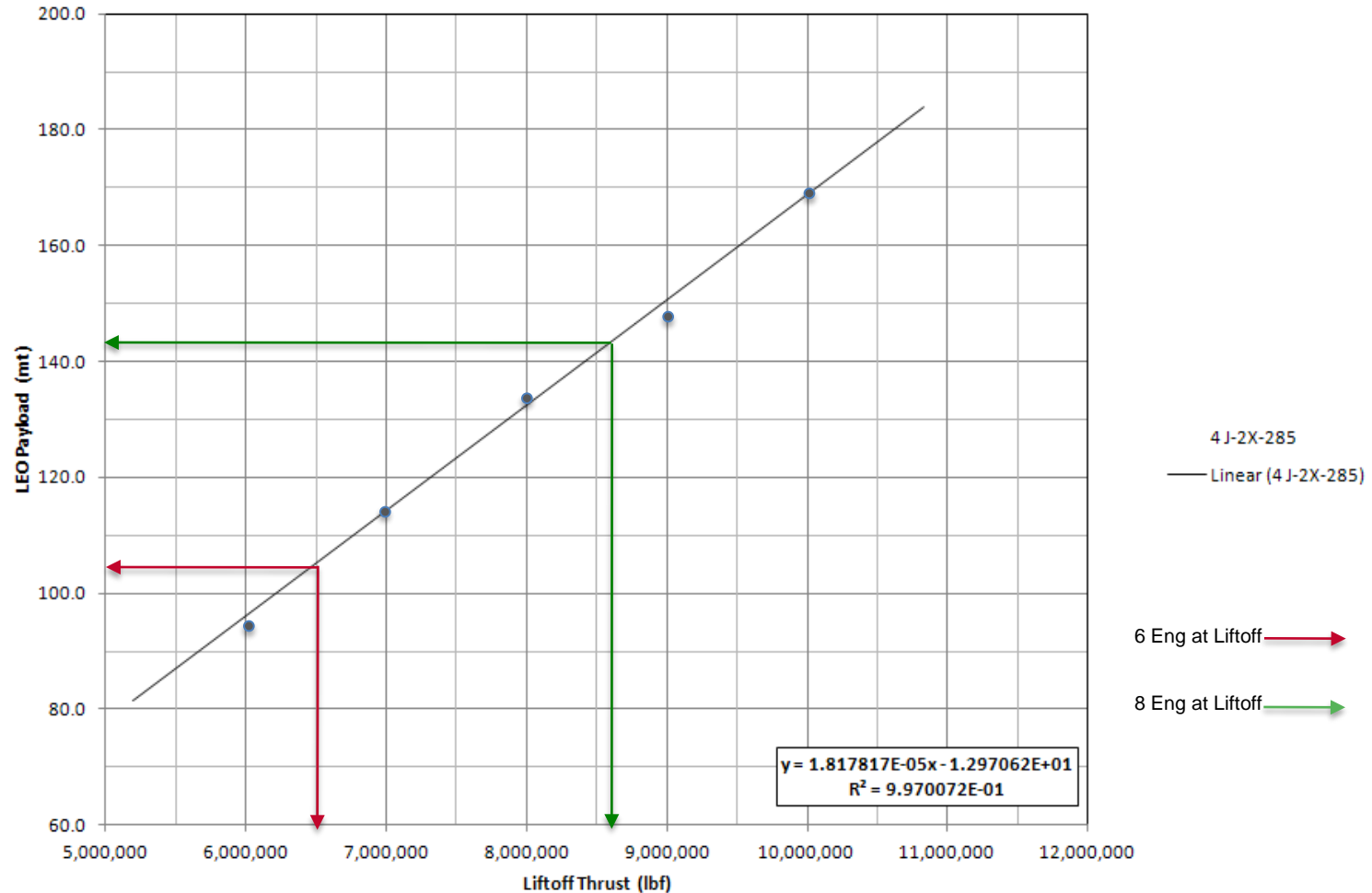
\* Engine Assumptions Provided by ER21 Propulsion Team at MSFC



# Payload to LEO as a Function of First Stage Thrust at Liftoff



For 100 MT Capability with Six First Stage Engines, NHE Thrust Requirement is 1.08 Mlbf @ SL / 1.25 Mlbf @ Vac per Engine



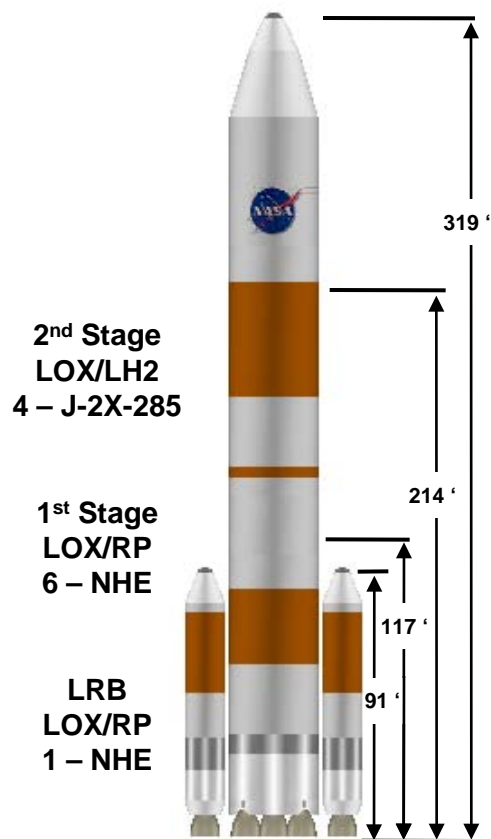




# Heavy Lift Vehicle Results



## 140 MT Vehicle

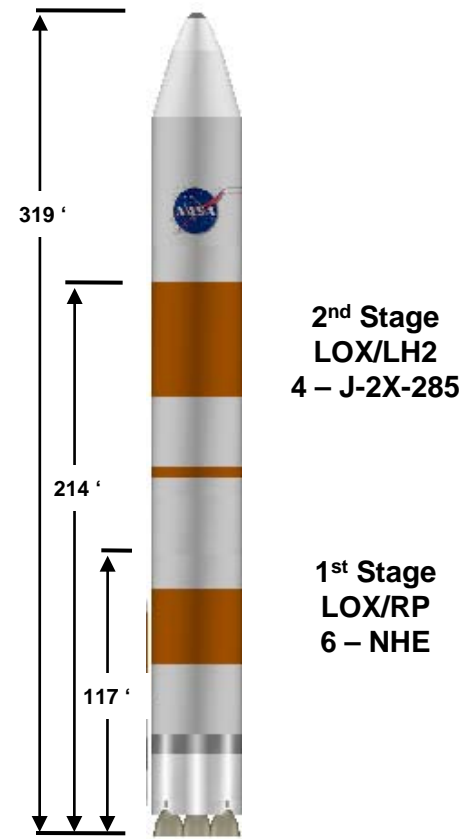


### Vehicle Data

(Emphasizing Commonality)

<u>140 MT</u>		<u>100 MT</u>
7.22 Mlb	GLOW	5.42 Mlb
33.2 Klb	Shroud	33.2 Klb
112 Klb	2 <sup>nd</sup> Stage Dry Wt.	112 Klb
1.08 Mlb	2 <sup>nd</sup> Stage Prop.	955 Klb (12.1% Offload)
339 Klb	1 <sup>st</sup> Stage Dry Wt.	337 Klb
4.07 Mlb	1 <sup>st</sup> Stage Prop.	3.69 Mlb (9.5% Offload)
91.8 Klb	LRB Dry Wt.	n/a
501 Klb	LRB Prop.	n/a
143.7 MT	Payload	104.2 MT

## 100 MT Vehicle



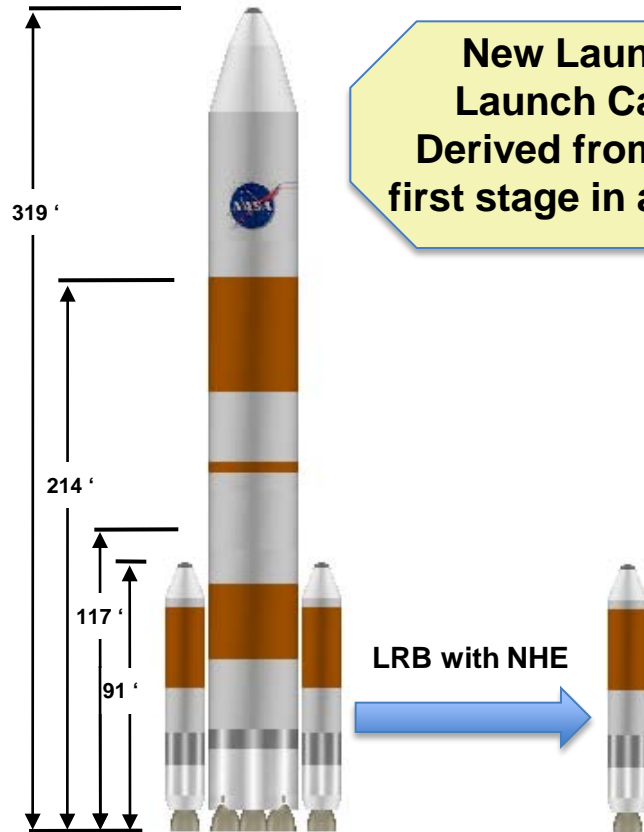


# Launch Vehicles from the NHE LRB



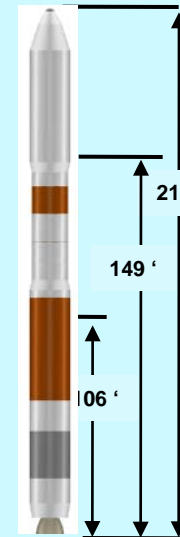
140 MT

New Launch Medium Class  
Launch Capability Could Be  
Derived from the LRB Used as a  
first stage in a series burn concept



Modify LRB by Increasing  
Propellant Load

Use LRB as is  
Remove Nosecone



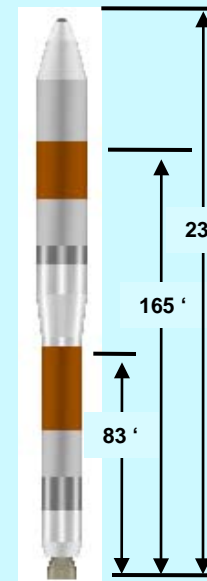
**GLOW**  
902 Klb

2nd Stage  
LOX/LH2  
2 – RL-10-A4-3

**Payload**  
11.5 MT LEO  
4-7 MT GTO  
depending on structural design

1st Stage  
LOX/RP  
1 – NHE

1st Stage Propellant – 719 Klb



**GLOW**  
901 Klb

2nd Stage  
LOX/LH2  
1 – J-2X-285

**Payload**  
12.9 MT LEO

1st Stage  
LOX/RP  
1 – NHE

1st Stage Propellant – 501 Klb



## Engine Out Capabilities of the 100 MT Vehicle



	Nominal	2 <sup>nd</sup> Stage EO	1 <sup>st</sup> Stage EO	EO Both Stages
GLOW	5.42 Mlb	5.42 Mlb	4.51 Mlb	4.51 Mlb
2 <sup>nd</sup> Stg Dry Mass	112 Klb	112 Klb	112 Klb	112 Klb
2 <sup>nd</sup> Stage Prop	955 Klb	655 Klb	963 Klb	656 Klb
2 <sup>nd</sup> Stg % Offload	12.1% Offload	40.0% Offload	11.4% Offload	39.6% Offload
1 <sup>st</sup> Stg Dry Mass	337 Klb	337 Klb	337 Klb	337 Klb
1 <sup>st</sup> Stg prop	3.69 Mlb	4.02 Mlb	2.83 Mlb	3.17 Mlb
1 <sup>st</sup> Stg % Offload	9.5% Offload	1.3% Offload	30.5% Offload	22.2% Offload
<b>Payload LEO</b>	<b>104.2 MT</b>	<b>89.0 MT</b>	<b>77.9 MT</b>	<b>65.1 MT</b>



# Summary



- **A Family of Launch Vehicle Concepts can be Derived from a New Hydrocarbon Stage Combustion Engine (NHE) to Meet Future Civil, Military, and Commercial Space**
  - NHE Thrust Requirement Determined at 1.25 MIbf @ Vacuum
  - Heavy Lift Capability in the 100 MT – 140 MT Class Defined
  - ELV Payload Class Capability with Single NHE
- **Stage Commonality Can Be Utilized and Still Meet Performance Requirements**
  - Reduced Development, Manufacturing, and Operations Costs
- **Missions Can Be Flown with Engine Out For Crewed Flights or High Value Payloads For Increased Launch Reliability**
  - Payload Capabilities of 65 MT to Nearly 90 MT can Still be Obtained with the 100 MT Vehicle Depending on the Amount of Engine Out is Desired